TMDLS FOR TURBIDITY
FOR VILLAGE CREEK, AR

FINAL
January 6, 2006

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FOR VILLAGE CREEK, AR

Prepared for

EPA Region VI
Water Quality Protection Division
Permits, Oversight, and TMDL Team
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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standards for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the waterbody.

The study area for this project is located in the Village Creek watershed in northeastern Arkansas. The study area is part of the Arkansas Department of Environmental Quality (ADEQ) Planning Segment 4C and is located within the Delta ecoregion. Land use in the study area is over 87% cropland, primarily soybeans and rice.

Five reaches in the Village Creek watershed are included on the draft 2004 Arkansas 303(d) list as not supporting the aquatic life use due to exceedances of numeric criteria for turbidity. In Arkansas Regulation No. 2, Village Creek is specified as a “channel-altered” stream. The numeric criteria for turbidity for channel-altered streams in the Delta ecoregion are 75 NTU (“primary” value) and 250 NTU (“storm-flow” value).

ADEQ historical water quality data were available for three locations along the impaired reaches of Village Creek. These data were analyzed for long term trends, seasonal patterns, relationships between concentration and stream flow, and relationships between turbidity and total suspended solids (TSS). These analyses showed no significant seasonal pattern or relationships between concentration and stream flow, but higher turbidity levels tended to correspond with higher TSS values.

These TMDLs were expressed using TSS as a surrogate for turbidity because turbidity cannot be expressed as a mass load. Two regressions between TSS and turbidity were developed for each ADEQ water quality monitoring station, one for base flow conditions and one for storm-flow conditions. The target TSS concentrations from two of the three water quality stations were averaged together because they were in the same reach. For base flow conditions, target TSS concentrations of 45 mg/L and 75 mg/L were used to correspond to the primary turbidity criterion of 75 NTU. For storm-flow conditions, target TSS concentrations of 61 mg/L and 123 mg/L were used to correspond to the storm-flow turbidity criterion of 250 NTU.

The TMDLs in this report were developed using the load duration curve methodology. This method illustrates allowable loading at a wide range of stream flow conditions. The steps for applying this methodology for the TMDLs in this report were:

1. Developing a flow duration curve,
2. Converting the flow duration curve to a load duration curve,
3. Plotting observed loads with the load duration curve,
4. Calculating the TMDL components, and
5. Calculating percent reductions.

The load duration curves were developed using multiple target TSS concentrations because Arkansas has different numeric turbidity criteria for different flow conditions. The target TSS concentrations corresponding to the primary turbidity criterion were applied between the 100% exceedance of stream flow and the 60% exceedance of stream flow. The target TSS concentrations corresponding to the storm-flow turbidity criterion were applied between the 60% exceedance of stream flow and the 0% exceedance of stream flow.

The wasteload allocations (WLAs) for point source contributions were set to zero because TSS in these TMDLs was considered to represent inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). The suspended solids discharged by point sources in the study area are assumed to consist primarily of organic solids rather than inorganic solids. Discharges of organic suspended solids from point sources are already addressed by ADEQ through their permitting of point sources to maintain water quality standards for dissolved oxygen. The WLAs to support these TMDLs will not require any changes to the permits concerning inorganic suspended solids. Therefore, future growth for these permits or new permits would not be restricted by these turbidity TMDLs.

An implicit margin of safety (MOS) was incorporated through the use of conservative assumptions. The primary conservative assumption was calculating the TMDLs assuming that TSS is a conservative parameter and does not settle out of the water column.

The TMDLs and percent reductions needed are summarized in Table ES.1.

Table ES.1. Summary of TMDLs and percent reductions.

Reach ID	Stream Name	Flow Category	Loads (tons/day of TSS)				Percent Reduction Needed
			WLA	LA	MOS	TMDL	
11010013-006	Village Creek	Base flow	0	3.88	0	3.88	0%
		Storm-flow	0	60.0	0	60.0	0%
11010013-007	Village Creek	Base flow	0	2.67	0	2.67	0%
		Storm-flow	0	41.4	0	41.4	0%
11010013-008	Village Creek	Base flow	0	2.43	0	2.43	0%
		Storm-flow	0	36.7	0	36.7	0%
11010013-012	Village Creek	Base flow	0	3.03	0	3.03	10%
		Storm-flow	0	57.7	0	57.7	0%
11010013-014	Village Creek	Base flow	0	1.82	0	1.82	10%
		Storm-flow	0	32.2	0	32.2	0%

The percent reductions shown in Table ES.1 were calculated using methodology that is slightly different than the assessment criteria used by ADEQ to develop the 2004 draft 303(d) list. These differences caused the assessment for the 2004 draft 303(d) list to indicate that five reaches of Village Creek are impaired and the TMDL analysis to indicate that several of these reaches are not impaired. The 2004 draft 303(d) list is still being reviewed by the Environmental Protection Agency (EPA) and has not been finalized yet.

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for siltation/turbidity for five reaches of Village Creek in northeastern Arkansas. These stream reaches were included on the Arkansas Department of Environmental Quality (ADEQ) draft 2004 Arkansas 303(d) list (ADEQ 2005a) as not supporting their designated use of aquatic life. The sources of contamination and causes of impairment from the 303(d) listing are shown below in Table 1.1. The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and the Environmental Protection Agency's (EPA) regulations in 40 CFR 130.7.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standards for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources, including natural background. The MOS is a percentage of the TMDL that takes into account any lack of knowledge concerning the relationship between pollutant loadings and water quality.

Table 1.1. 303(d) listing for stream reaches in this task order.

Reach No.	Stream Name	Sources	Causes	Category	Priority
11010013-006	Village Creek	Agriculture	Siltation/turbidity	5b	Low
11010013-007	Village Creek	Agriculture	Siltation/turbidity	5b	Low
11010013-008	Village Creek	Agriculture	Siltation/turbidity	5b	Low
11010013-012	Village Creek	Agriculture	Siltation/turbidity	5b	Low
11010013-014	Village Creek	Agriculture	Siltation/turbidity	5b	Low

2.0 BACKGROUND INFORMATION

2.1 General Information

The study area for this project is the Village Creek watershed in northeastern Arkansas (see Figure A.1 in Appendix A). The Village Creek watershed is in the Delta ecoregion and in ADEQ Planning Segment 4C. Village Creek is also in United States Geological Survey (USGS) Hydrologic Unit 11010013. The study area covers 294 square miles and includes parts of Randolph, Lawrence, and Jackson Counties.

2.2 Soils and Topography

The soils and topography information was obtained from soil surveys for Randolph, Lawrence, and Jackson Counties (United States Department of Agriculture (USDA) 1980, USDA 1978, USDA 1974). The soils in the study area are mostly loamy and clayey soils. The topography of most of the study area is characterized by flat plains with a few rolling hills in the northern and southern area of the watershed.

2.3 Land Use

Land use data for the study area were obtained from the GEOSTOR database, which is maintained by the Center for Advanced Spatial Technology (CAST) at the University of Arkansas in Fayetteville. These data were based on satellite imagery from 1999. The spatial distribution of these land use is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that the most of the study area consists of cropland, primarily soybeans and rice.

Table 2.1. Land use percentages for the study area.

Land use	Percentage of Study Area
Urban	4.9%
Barren/Fallow	0.1%
Water	0.9%
Forest (all types)	6.3%
Soybeans	57.5%
Rice	24.4%
Corn	5.9%
Total	100.0%

2.4 Description of Hydrology

Average precipitation for the study area is about 46 to 50 inches per year (USGS 1985). There is no USGS flow gage in the study area so a nearby gage was used. The USGS gage on Cache River at Egypt, Arkansas (07077380) was chosen since it is close to Village Creek and its watershed has similar land use and topography. Information for this flow gage is summarized in Table 2.2.

Table 2.2. Information for USGS stream flow gaging station (USGS 2005).

Gage name:	Cache River at Egypt, AR
Gage number:	07077380
Descriptive location:	Bridge at State Highway 91, 1 mile southeast of Egypt
Period of record:	October 1964 to September 2004
Drainage area:	701 square miles
Mean daily flow:	868 cfs
Median daily flow:	328 cfs

2.5 Water Quality Standards

Water quality standards for Arkansas waterbodies are listed by ecoregion in Regulation No. 2 (Arkansas Pollution Control and Ecology Commission (APCEC) 2004a). Designated uses for Village Creek include primary and secondary contact recreation; public, industrial, and agricultural water supply; and perennial Delta fishery (where the drainage area is 10 square miles or more).

Section 2.503 of Regulation No. 2 provides both a narrative criterion and numeric criteria that apply to siltation/turbidity. The general narrative criterion is: “There shall be no distinctly visible increase in turbidity of receiving waters attributable to municipal, industrial, agricultural, other waste discharges or instream activities.” There are two sets of numeric criteria for turbidity in this ecoregion, one set for “least-altered” streams and one set for “channel-altered” streams. Appendix A of Regulation No. 2 specifies Village Creek as a channel-altered stream. The numeric turbidity criteria for channel-altered streams in the Delta ecoregion are 75 NTU (“primary” value) and 250 NTU (“storm-flow” value). The regulation also states that “the non-point source runoff shall not result in the exceedance of the in stream storm-flow values in more than 20% of the ADEQ ambient monitoring network samples taken in not less than 24 monthly samples.”

As specified in EPA's regulations at 40 CFR 130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is listed in Sections 2.201 through 2.204 of Regulation No. 2. These sections impose the following requirements:

- Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
- Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development, although water quality must still be adequate to fully protect existing uses.
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.
- For potential water quality impairments associated with a thermal discharge, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act.

2.6 Nonpoint Sources

In the 2004 303(d) list, the source of turbidity for Village Creek is listed as agriculture. As shown in Table 2.1, over 87% of the Village Creek watershed is cropland, which typically has greater soil erosion than other land uses such as forest or pasture.

2.7 Point Sources

Information for point source discharges in the study area was obtained by searching the Permit Compliance System on the EPA web site (PCS 2005). The search yielded 11 facilities with point source discharges. Search results, including flow rate and permit limits for total suspended solids (TSS), are included in Table 2.3. Locations of the permitted facilities are shown on Figure A.3 in Appendix A.

Table 2.3. Inventory of point source dischargers.

NPDES Permit No.	Facility Name	Receiving Water	Flow Rate (MGD)	Monthly Average TSS Limits (mg/L)
AR0001481	Norandal USA Inc.	Ditch, Village Creek	0.72	--
AR0020001	City of Tuckerman	Tuckerman Ditch Creek, Village Creek	0.225	30
AR0020141	City of Hoxie	Tributary, Turkey Creek, Village Creek	0.41	20
AR0034550	Arkansas Steel Association	Tributary, Village Creek, White River	0.246	30
AR0034860	City of Swifton	Cattail Creek, Village Creek, White River	0.11	20
AR0036668	Frit Industries Inc.	Tributary, Coon Creek, Village Creek, White River	0.041	0/60 (seasonal)
AR0039675	City of Alicia	Black Spice Ditch	0.03	15
AR0041033	Diaz Wastewater	Ditch, Village Creek, White River	0.23	90
AR0045225	Newport Airport/ Indus. Park WWTP	Tributary, Locust Creek, Village Creek	0.2	15
AR0046566	Walnut Ridge WWTP	Village Creek, White River	1.19	15
ARG790077	Former Williams #7326	Storm drain, White River	0.036	--

3.0 EXISTING WATER QUALITY FOR TURBIDITY AND TSS

3.1 General Description of Data

Turbidity and TSS data have been collected by ADEQ at three sites in the study area. The locations of these sampling sites are shown on Figure A.4 (located in Appendix A). TSS data are discussed here because TSS is needed as a surrogate parameter for expressing the siltation/turbidity TMDLs. These turbidity and TSS data were obtained from the ADEQ web site (ADEQ 2005b) and are summarized in Table 3.1. The individual data are listed in Tables B.1-B.3 and shown graphically as time series plots on Figures B.1-B.6 (located in Appendix B). The data for these sampling stations are stored in the ADEQ database with "UWVGC01", "UWVGC02", and "UWVGC03" as the station names, but these stations are referred to by their common descriptors of "VGC0001", "VGC0002", and "VGC0003" throughout this report.

Table 3.1. Summary of ADEQ data for turbidity and TSS.

Station	Description	Parameter	Count	Min.	Median	Average	Max.
VGC0001	Village Creek at Hwy. 37, 3 mi. E. of Tuckerman, AR	Turbidity	19	10	76	54	250
		TSS	19	9	28	22	69
VGC0002	Village Creek at Hwy. 228 at Minturn, AR	Turbidity	20	11	102	78	280
		TSS	20	9	72	76	163
VGC0003	Village Creek at Hwy. 224 near Newport, AR	Turbidity	18	4	50	45	113
		TSS	19	3	26	19	85

Tables B.1-B.3 include comparisons between the observed turbidity data and the numeric water quality criteria. These comparisons required the observed data to be separated into base flow data (to be compared with the "primary" criterion) and storm-flow data (to be compared with the "storm-flow" criterion). It was assumed here that the lowest 40% of stream flow values represent flow conditions without significant influence from storm runoff and that stream flow values above the 40th percentile would have some influence from storm runoff. The turbidity data were considered to be base flow data when the flow on the sampling day at the USGS gage on the Cache River at Egypt was 189 cfs or less (the 40th percentile flow, or the flow that was exceeded 60% of the time). The turbidity data were considered to be storm-flow data when the flow on the sampling day at the USGS gage on the Cache River at Egypt was greater than 189 cfs. Tables B.1-B.3 show that the turbidity data collected during base flow conditions exceeded the primary criterion 30%, 30%, and 18% of the time at stations VGC0001, VGC0002, and VGC0003, respectively. These tables also show that turbidity data collected during storm-flow conditions exceeded the storm-flow criterion 0%, 10%, and 0% of the time at stations VGC0001, VGC0002, and VGC0003, respectively.

3.2 Seasonal Patterns

Seasonal plots of turbidity and TSS are shown on Figures C.1-C.6 (located in Appendix C). These plots showed a limited seasonal pattern, with higher values measured at the beginning of the year.

3.3 Relationships Between Concentration and Flow

Plots of turbidity and TSS versus stream flow were also developed to examine any correlation between these two parameters and flow (Figures D.1-D.6, located in Appendix D). These plots showed no noticeable relationship between concentration and flow.

3.4 Relationships Between TSS and Turbidity

Plots and regression analyses were used to examine relationships between TSS and turbidity. The regressions were performed using the natural logarithms of the data (rather than the raw data values) because most data such as turbidity and TSS fit a lognormal distribution better than a normal distribution.

Separate plots and regression analyses were developed for base flow conditions and storm-flow conditions to be consistent with the numeric criteria for turbidity. The plots and linear regressions for base flow conditions (Figures E.1, E.3, and E.5) use only the base flow data. The plots and linear regressions for storm-flow conditions (Figures E.2, E.4, and E.6) use all of the data regardless of flow on the sampling day. The data collected under base flow conditions were included in the storm-flow regressions in order to maximize the accuracy of the lower end of the regression lines that corresponds to turbidity values near the numeric criteria.

All of the plots show noticeable correlations, with higher turbidity levels tending to correspond with higher TSS concentrations. The results of the linear regression analyses are summarized in Table 3.2.

Table 3.2. Results of regressions between TSS and turbidity.

Sampling Station	Category	Regression Equation	Number of Data	R^2	Significance Level (P value)
VGC0001	Base flow	ln TSS = 0.644 * ln Turbidity + 0.887	9	0.79	1.2×10^{-2}
	Storm-flow	ln TSS = 0.527 * ln Turbidity + 1.096	18	0.55	4.2×10^{-4}
VGC0002	Base flow	ln TSS = 0.964 * ln Turbidity + 0.151	9	0.89	1.2×10^{-3}
	Storm-flow	ln TSS = 0.631 * ln Turbidity + 1.324	19	0.50	7.6×10^{-4}
VGC0003	Base flow	ln TSS = 0.847 * ln Turbidity + 0.261	11	0.86	6.3×10^{-4}
	Storm-flow	ln TSS = 0.616 * ln Turbidity + 0.794	18	0.57	2.7×10^{-4}

The strength of the linear relationship is measured by the coefficient of determination (R^2) calculated during the regression analysis (Zar 1996). The R^2 value is the percentage of the total variation in ln TSS that is explained or accounted for by the fitted regression (ln turbidity). For example, in the VCG0001 base flow regression above, 79% of the variation in TSS is accounted for by turbidity and the remaining 21% of variation in TSS is unexplained. The unexplained portion is attributed to factors other than the measured value of turbidity.

These regressions show a majority of the measurement of the turbidity (NTU) is explained by the measured concentration of TSS. The perfect explanation of the measurement of turbidity to the measurement of TSS would require collecting and analyzing a large amount of data. A number of the items effecting this perfect explanation of the relationship would need to be known. A partial list of the items effecting the relationship follows:

- Velocity of the water at the time of sampling;
- Carbonaceous biochemical oxygen demand (CBOD) concentration;
- Ammonia concentration;
- Nitrate concentration;
- Phosphorus concentration;
- Algal mass in the water column;
- Bacteria mass in the water;
- Measured color of the water;
- Mass of the organic component of the TSS;
- Mass of the material passing through the filter during the TSS analysis;
- Grain size distribution of the inorganic portion of the TSS;
- Specific gravity of the different sizes of inorganic solids particles;
- Hydrograph for the stream;
- Position on the hydrograph (i.e., rising limb, falling limb) at the time of sampling;
- Number of overlapping rainfall events represented by this sample day;
- Magnitude of each of the rainfall events represented by this sample day; and
- Lags of the overlapping rainfall events represented by this sample day.

The collection of the above data would not change the fact that inorganic particles represented in the TSS measurements is the major contributor to the turbidity reading and is the major constituent reduced when sediment BMPs are applied to nonpoint sources. The BMPs used on nonpoint sources for sediment also reduce the load of many of the unexplained contributors in the regression. The effort to have a perfect explanation of turbidity may not result in a better selection of BMPs. The regressions presented above between TSS and turbidity are adequate for the preparation of this TMDL. A stakeholder group of knowledgeable persons from the watershed may need additional information to set a plan of action for this TMDL.

The correlations between turbidity and TSS for Village Creek were considered to be good; the R^2 values for these regressions (which range from 0.50 to 0.89) are higher than or similar to R^2 values for turbidity and TSS from other approved TMDLs in Arkansas (FTN Associates, Ltd. (FTN) 2001, FTN 2003, FTN 2005).

The statistical significance of the regression was evaluated by computing the "P value" for the slope of the regression line. The P value is essentially the probability that the slope of the regression line is really zero. Thus, a low P value indicates that a non-zero slope calculated from the regression analysis is statistically significant. For these regressions, the P values are quite small and are considered good.

4.0 TMDL DEVELOPMENT

4.1 Seasonality and Critical Conditions

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. The historical data analysis in Section 3.0 showed little or no correlation between turbidity levels and either season of the year or streamflow. Therefore, there is not a critical season or a single critical flow for these TMDLs. The methodology used to develop these TMDLs (load duration curve) addresses allowable loading for a wide range of flow conditions.

4.2 Water Quality Targets

Turbidity is an expression of the optical properties in a water sample that cause light to be scattered or absorbed and may be caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms (Standard Methods 1999). Turbidity cannot be expressed as a load as preferred for TMDLs. To achieve a load based value, turbidity is often correlated with a surrogate parameter such as TSS that may be expressed as a load. In general, activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (EPA 1991). Research by Relyea et. al. (2000) states, "increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrophs to substrate surfaces".

For the turbidity TMDLs in this report, the relationships between turbidity and TSS presented in Table 3.2 were used to develop target TSS concentrations (i.e., numeric endpoints for the TMDLs). Two target TSS concentrations were developed for each water quality monitoring station. One target was developed using the base flow regression and the primary turbidity criterion and the other target was developed using the storm-flow regression and the storm-flow turbidity criterion. The target TSS concentrations are shown in Table 4.1. The discussion in Section 3.1 associating the primary turbidity criterion with the base flow portion of the duration curve is the basis for using the descriptor "base flow" in this document for the conditions when the primary turbidity criterion should apply.

Because stations VGC0001 and VGC0003 are both located on the same reach of Village Creek (11010013-006), the target TSS concentrations calculated for each of those two stations were averaged together. Several of the impaired reaches of Village Creek do not have any water quality monitoring data. Target TSS values for those reaches were set equal to the target values from the nearest reach with water quality monitoring data.

Table 4.1. TSS target concentrations.

Water Quality Station	Regression	Turbidity Criterion	Target TSS	Reaches to Which Targets were Applied
VGC0001	Base flow	75 NTU	39 mg/L	None
	Storm-flow	250 NTU	55 mg/L	
VGC0003	Base flow	75 NTU	50 mg/L	None
	Storm-flow	250 NTU	66 mg/L	
Average of VGC0001 and VGC0003	Base flow	75 NTU	45 mg/L	11010013-006, -007, -008
	Storm-flow	250 NTU	61 mg/L	
VGC0002	Base flow	75 NTU	75 mg/L	11010013-012, -014
	Storm-flow	250 NTU	123 mg/L	

4.3 Methodology for TMDL Calculations

The methodology used for the TMDLs in this report is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represent a continuum of desired loads over all flow conditions, rather than fixed at a single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment web site (KDHE 2005). This method was used to illustrate allowable loading at a wide range of flows. The steps for how this methodology was applied for the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve (Section 4.4);
2. Convert the flow duration curve to load duration curves (Section 4.5);
3. Plot observed loads with load duration curves (Section 4.6);

4. Calculate TMDL, MOS, WLA, and LA (Sections 4.7-4.9); and
5. Calculate percent reductions (Section 4.10).

4.4 Flow Duration Curve

A flow per unit area duration curve was developed for the whole study area (see Tables F.1-F.2 in Appendix F for details). Daily streamflow measurements for the Cache River at Egypt (USGS Gage No. 07077380) were sorted in increasing order and the percent exceedance of each flow was calculated. The flow was divided by the drainage area of the gage to get a flow per square mile. The flow per unit area duration curve is shown on Figure F.1 in Appendix F.

4.5 Load Duration Curves

Each flow per unit area from the flow duration curve was multiplied by the appropriate TSS target concentration to develop plots of allowable load versus flow exceedance (load duration curves). The water quality standards for Arkansas (APCEC 2004a) do not specify a range of flows or flow exceedances for which each of the turbidity criteria (primary and storm-flow) is applicable. As discussed in Section 3.1, it was assumed here that the lowest 40% of stream flow values represent flow conditions without significant influence from storm runoff and that stream flow values above the 40th percentile would have some influence from storm runoff. Therefore, the TSS target corresponding to the primary turbidity standard was applied to the lowest 40% of flows (from 100% exceedance of stream flow to 60% exceedance of stream flow). The TSS target corresponding to the storm-flow turbidity criterion was applied from 60% exceedance of stream flow to 0% exceedance of stream flow. The load duration curves for storm-flow conditions and base flow conditions are shown on Figures F.2-F.7 (in Appendix F).

4.6 Observed Loads

The observed loads per unit of drainage area for all three Village Creek water quality stations were calculated for each sampling day. Each observed load per unit of drainage area was calculated by simply multiplying the observed TSS concentration times the flow per unit of drainage area on the sampling day (with a conversion factor incorporated).

The load duration plots (Figures F.2-F.7) provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions where observed water quality concentrations exceed the target concentrations. Observed loads below the load duration curve represent conditions where observed water quality concentrations were less than target concentrations (i.e., not exceeding water quality criteria).

4.7 TMDL and MOS

The allowable loads per unit area for storm-flow conditions were calculated as the appropriate TSS target for storm-flow conditions (61 mg/L or 123 mg/L) multiplied times the flow per unit area at the 30% flow exceedance. The 30% flow exceedance was used because it is considered to represent a typical flow value for storm-flow conditions (it is the midpoint along the flow duration curve between 0% and 60%). The allowable loads per unit area for base flow conditions were calculated as the appropriate TSS target for base flow conditions (45 mg/L or 75 mg/L) multiplied times the flow per unit area at the 80% flow exceedance. The 80% flow exceedance was used because it is considered to represent a typical flow value for base flow conditions (it is the midpoint along the flow duration curve between 60% and 100%). The TMDLs were calculated as the allowable loads per unit area multiplied times the total drainage area at the downstream end of each reach. These calculations are shown at the bottom of Tables F.1 and F.2.

Both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to include a MOS to account for uncertainty in available data or in the actual effect that controls will have on the loading reductions and receiving water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly through conservative assumptions used in establishing the TMDL. For these TMDLs, an implicit MOS was incorporated through the use of conservative assumptions. The primary conservative assumption was calculating the TMDLs assuming that TSS is a conservative parameter and does not settle out of the water column.

4.8 Point Source Loads

The WLAs for the point sources were set to zero because the surrogate being used for turbidity (TSS) is considered to represent inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). The suspended solids discharged by point sources in the Village Creek watershed are assumed to consist primarily of organic solids rather than inorganic solids. Discharges of organic suspended solids from point sources are already addressed by ADEQ through their permitting of point sources to maintain water quality standards for dissolved oxygen. The WLAs to support these TMDLs will not require any changes to the permits concerning inorganic suspended solids. Therefore, future growth for these permits or new permits would not be restricted by these turbidity TMDLs.

4.9 Nonpoint Source Loads

The LAs for nonpoint sources, including natural background, result in being equal to the TMDLs because the WLAs were zero and the MOS was implicit.

4.10 Percent Reductions

In addition to calculating allowable loads, estimates were made for percent reductions of nonpoint source loads that are needed. For each observed TSS load that exceeded the allowable load at that flow (i.e., each observed TSS load above the allowable load curve in Figures F.2-F.7), a uniform percent reduction was applied to the observed loads on that plot until the number of TSS loads exceeding the allowable loads was less than or equal to an acceptable number. For storm-flow conditions, the acceptable number of exceedances was 20% of the number of storm-flow data. This percentage (20%) was based on the Arkansas water quality standards, which state that “the non-point source runoff shall not result in the exceedance of the in stream storm-flow values in more than 20% of the ADEQ ambient monitoring network samples taken in not less than 24 monthly samples.” (APCEC 2004a). For base flow conditions, the acceptable number of exceedances was 25% of the number of base flow data. This percentage (25%) was based on the ADEQ assessment criteria for turbidity (ADEQ 2002, ADEQ 2005a). For both storm-flow and base flow conditions, whenever the appropriate percentage multiplied by the number of observed values yielded a fractional number (e.g., 25% x 38 = 9.5), the allowable number of exceedances was rounded up to the next whole number (e.g., 9.5 rounded up to 10) in accordance with the ADEQ assessment criteria (ADEQ 2002, ADEQ 2005a). The calculations for percent reductions are shown in Tables F.3-F.8.

For the Village Creek reaches without water quality monitoring data, percent reductions were assumed to be the same as for the nearest reach with observed water quality data (i.e., in a similar manner as done for the target TSS concentrations). The percent reductions and the results of the TMDL calculations are summarized in Table 4.2.

Table 4.2. Summary of turbidity TMDLs.

Reach ID	Stream Name	Flow Category	Loads (tons/day of TSS)				Percent Reduction Needed
			WLA	LA	MOS	TMDL	
11010013-006	Village Creek	Base flow	0	3.88	0	3.88	0%
		Storm-flow	0	60.0	0	60.0	0%
11010013-007	Village Creek	Base flow	0	2.67	0	2.67	0%
		Storm-flow	0	41.4	0	41.4	0%
11010013-008	Village Creek	Base flow	0	2.43	0	2.43	0%
		Storm-flow	0	36.7	0	36.7	0%
11010013-012	Village Creek	Base flow	0	3.03	0	3.03	10%
		Storm-flow	0	57.7	0	57.7	0%
11010013-014	Village Creek	Base flow	0	1.82	0	1.82	10%
		Storm-flow	0	32.2	0	32.2	0%

The percent reductions in Table 4.2 were calculated using methodology that is slightly different than the assessment criteria used by ADEQ to develop the 2004 303(d) list. The ADEQ assessment was performed using turbidity data that were categorized as either base flow or storm-flow values based on the month of the year in which the values were measured. The percent reductions in Table 4.2 were calculated using TSS data that were categorized as either base flow or storm-flow values based on streamflow data on each sampling day. These differences caused the assessment for the 2004 draft 303(d) list to indicate five reaches of Village Creek are impaired and the TMDL analysis to indicate that several of these reaches are not impaired. The 2004 draft 303(d) list is still being reviewed by EPA and has not been finalized yet.

4.11 Future Growth

As mentioned in Section 4.8, future growth of existing or new point source discharges would not be restricted by these TMDLs.

5.0 OTHER RELEVANT INFORMATION

In accordance with Section 106 of the federal Clean Water Act and under its own authority, ADEQ has established a comprehensive program for monitoring the quality of the State's surface waters. ADEQ collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for long term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (*Water Quality Inventory*) and the 303(d) list of impaired waters, which are issued as a single document titled Arkansas Integrated Water Quality Monitoring and Assessment Report.

6.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, federal regulations require EPA to publicly notice and seek comment concerning the TMDL. Pursuant to a May 2000 consent decree, these TMDLs were prepared under contract to EPA. After development of the draft version of these TMDLs, EPA prepared a notice seeking comments, information, and data from the general public and affected public. No comments, data, or information were submitted during the public comment period. EPA has transmitted the final TMDLs to ADEQ for implementation and for incorporation into ADEQ's current water quality management plan.

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